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Tasmania Department Of Resources and Energy

Division of Mines and Mineral Resources — Report 1991/22

Some physical properties of dolerite

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Abstract

Dolerite, an igneous rock, is exposed over half of Tasmania. The good physical and chemical properties of the rock make it suitable for a wide variety of uses. Crushed rock is used as aggregate in concrete, as road sub-base and in flush seals, as facing stone in building construction, and as armour stone and rip-rap.

INTRODUCTION

Following a request for information concerning the physical properties of dolerite, a brief attempt was made to collate such information. Fresh dolerite rock is considered to be very strong and is not greatly affected by weathering. The uses for this rock are widely accepted and its physical properties are suitable for most purposes. This appears to account for the difficulty in obtaining test information, a reason confirmed by some of the information sources contacted.

Information concerning the strength properties was sought from: Rivers and Water Supply Division; University of Tasmania; Hydro-Electric Commission; major quarry companies; consultant engineers; Division of Mines and Mineral Resources; Concrete Association; and the Department of Roads and Transport.

GEOLOGY

Dolerite is an igneous rock, that is, rock initially molten and injected as a fluid into older sedimentary rocks. The magma, of quartz tholeiite composition, was emplaced as a liquid which rose upwards through the basement rocks into older sedimentary rocks of the Parmeener Supergroup. Emplacement probably occurred over an interval of 20 million years, and the average age of the rock is middle Jurassic, approximately 175 Ma (Hergt *et al.*, 1989).

Approximately half the area of Tasmania is underlain by Jurassic dolerite. The estimated volume of dolerite is of the order of 15 000 km^3 (Hergt *et al.*, 1989).

Dolerite is composed of two essential and several accessory minerals. The essential minerals are plagioclase feldspar and pyroxene, which together constitute between about 60% and 80% of the total rock composition. The accessory minerals are quartz, orthoclase, chlorite and magnetite. Quartz, orthoclase and chlorite may comprise 20% to 40% of the rock while the magnetite composition may be 2% to 3% (Leaman, 1973).

Numerous quarries occur throughout the State, with preferable sites close to contacts where jointing is platy. Decomposed, usually coarse-grained granophyric dolerite is used for surfacing unsealed roads.

PHYSICAL PROPERTIES

The physical and chemical properties of dolerite make it highly suitable for a variety of purposes. It is used mainly as crushed aggregate in concrete production, as road sub-base and in flush seals, facing stone in building construction, and as armour stone and rip-rap.

The physical properties of dolerite are given below for various localities. There is, however, no rock description for some sites. It can only be assumed that the tests were conducted on the best representative samples for each site. The physical properties of dolerite will vary depending on the grainsize, composition, degree of weathering and physical defects.

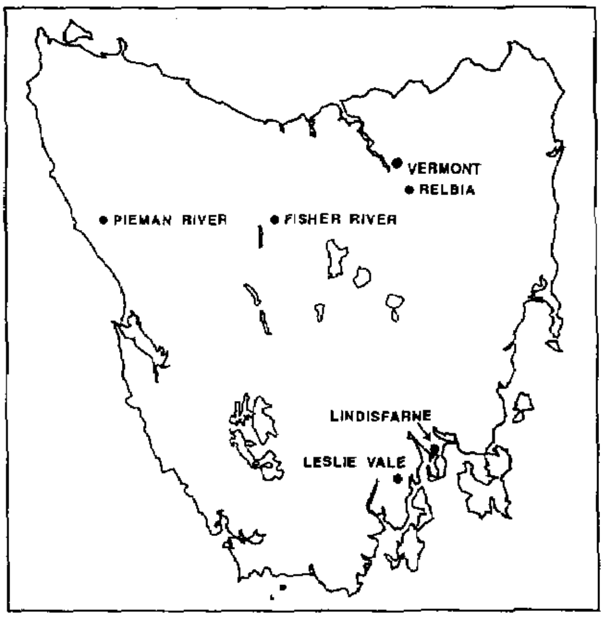


Figure 1. Location of sites of tested materials

5 cm

Leaman (1972) provided a general summary of the physical properties of dolerite for the Hobart area. The source of this information is not known but the information may be useful as a general guide.

Density:	2.80–3.10 t/m^3 (average 2.9–2.95 t/m^3)
Poissons ratio:	0.02–0.1 (weathered) 0.3–0.4 (unweathered)
Youngs modulus:	10–40 GPa (weathered) 90–110 GPa (unweathered)
Bulk modulus:	5–30 GPa (weathered) 90–100 GPa (unweathered)
Rigidity modulus:	10–50 GPa (unweathered)
Uniaxial compressive strength:	40 MPa (unweathered)
Porosity:	Approximately 1%

The physical property results from tests obtained at various specific sites (fig. 1) are presented below.

Density

Apparent Density

Lindisfarne:	2.91 t/m^3 (date ?) 2.905 t/m^3 (June 1989) 2.88 t/m^3 (20 mm screenings) 2.73 t/m^3 (37 mm crusher run)

Bulk Density — Saturated surface dry

Relbia:	2.89 t/m^3
Lindisfarne:	2.865 t/m^3 2.85 t/m^3 (20 mm screenings) 2.68 t/m^3 (37 mm crusher run)
Fisher:	3.01 t/m^3 (figure quoted as 'density', samples air dried and saturated prior to testing)

Bulk Density — Oven Dry

Relbia:	2.87 t/m^3
Lindisfarne:	2.84 t/m^3 2.83 t/m^3 (20 mm screenings) 2.65 t/m^3 (37 mm crusher run)
*Pieman (1978):	2.96 t/m^3 (mean of 18 samples) 2.95–3.004 t/m^3 (range for good quality rock)
*Pieman (1983):	2.971 t/m^3 ('Hard' rock — mean of 9 samples) 2.935 t/m^3 ('Soft' rock — mean of 10 samples)

*N.B. Results quoted as 'Dry Density'. The Pieman (1983) results subdivided samples into 'hard' and 'soft' categories, depending on the ease of percussion drilling.

Water Absorption

Relbia:	0.6%	
Lindisfarne:	0.9%	
Lindisfarne:	1.09% 0.56%	(37 mm crusher run) (20 mm screenings)
Pieman (1978):	0.7% 0.3–0.6%	(mean of 20 samples) (range of values — good quality rock)
Pieman (1983):	0.28% 0.35%	('Hard' rock — mean of 9 samples) ('Soft' rock — mean of 10 samples)

Unconfined Compressive Strength

Relbia: Core 1 — 90 MPa
Core 2 — 125 MPa
Mean — 108 MPa
(50 mm diameter core approximately 200 mm in length)

Pieman (1978):	171 MPa (mean of 18 samples) 91–282 MPa (general range for good quality rock, although one sample gave 369 MPa)
Pieman (1983):	253 MPa ('Hard' rock — mean of 9 samples) 173 MPa ('Soft' rock — mean of 10 samples)
Fisher:	Mean 91 MPa (range of results was 30–155 MPa)

Schmidt Hardness

Pieman (1983): 43–44 for good quality fresh rock

Wet/Dry Strength

Lindisfarne: Dry strength = 282 kN
Wet strength = 197 kN
Wet/Dry variation = 30%

Los Angeles Test Values

Lindisfarne:	Los Angeles Test 'A' grading 1985 — 16.5% (37 mm crusher run)
Lindisfarne:	March 1989 — 15.0% August 1990 — 15.0% April 1991 — 14.5%
Pieman (1978):	Los Angeles Test 'B' grading

Sample	*% loss*	*Quality*	*RQD (%)*	*Weathering*
1	13.7	Good	95	Fresh
2	9.7	Good	95–100	Fresh
3	14.5	Poor	0–75	Partly weathered
4	16.5	Poor	0–50	Partly weathered
5	6.3	Good	100	Fresh

Vermont:	Los Angeles Test 'B' grading 14% (16 mm aggregate)

Polished Aggregate Friction Values

Lindisfarne:	52 (RCA Victoria Method 374.01)
Leslie Vale:	51 (AS1141-41/42)
Vermont:	46 (AS1141-41/42) (14 mm aggregate) 45 (10 mm aggregate)

California Bearing Ratio

Vermont:	220 (37 mm crusher run)

Point Load Strength

Pieman (1978): Is (50) MPa for 20 specimens. Refers to above samples.

Sample	*Median*	*Mean*	*Standard Deviation*	*Weathering*
1	15.4	14.5	3.1	Fresh
2	13.4	11.6	5.6	Fresh
3	6.5	7.2	4.5	Partly weathered
4	4.2	4.6	3.1	Partly weathered
5	17.0	16.6	1.4	Fresh

Pieman (1983): Is (50) MPa for 20 specimens;

For 'Hard' rock	Mean — 18.1 (range 3.4 to 21.6)
For 'Soft' rock	Mean — 10.7 (range 2.6 to 20.7)

Young's Modulus

Pieman (1978)

Dynamic	93 GPa (mean of 18 samples) 87–102 GPa (range for good quality rock)
Static	96 GPa (mean of 5 samples) 101–110 GPa (range for good quality rock)

Pieman (1983)

Dynamic	102 GPa	('Hard' rock – mean of 9 samples)
	97 GPa	('Soft' rock – mean of 10 samples)

Poisson's Ratio

Pieman	0.22 (mean of 5 samples) 0.217–0.240 (range for good quality rock)

Petrographic Descriptions

Lindisfarne

Rock species –	diabase
Plagioclase –	63%
Augite –	37%
Texture –	no orientation, even-grained, dominant grain size 0.5 mm. No weathering.
Vickers hardness –	740
Drillability Index –	PNI = 32 Drilling rate index = 31 Friability index (S_{20}') = 31 PROTO 20 = 23, s = 1.1 Sievers J value (SJ') = 10, s = 3.8

Relbia — Sample 1

Dolerite. Fine grained, ophitic texture.

Primary minerals — plagioclase, pyroxene, hornblende and quartz. Acicular and lath-like plagioclase, equant grains of pyroxene — some alteration to chlorite along cleavage and fissures. Secondary minerals (10%) include chlorite. Quartz content 10%.

Relbia — Sample 2

Dolerite. Fine grained, ophitic texture.

Primary minerals — plagioclase, pyroxene, amphibole. Plagioclase crystals acicular, pyroxene grains subhedral with chloritised outlines. Secondary minerals (13.5%) include chlorite and quartz (8.8%).

Pavement Skid Resistance

Information source: *Relative Performance of Basalt and Dolerite Flush Seals* (DRT Report 85/93)

Summary

Test programme included a range of seal ages, traffic densities and curve radii. Skid resistance properties measured using the British Pendulum Tester. Testing generally done during winter months.

Test result trends are shown in Figure 2, where BPN skid resistance values vs. total vehicles (from AADI counts and years in service) are shown for curve radii greater than 500 m, between 500 m and 100 m, and less than or equal to 100 m. The results showed no positive indication of BPN values being a function of aggregate size (10–16 mm).

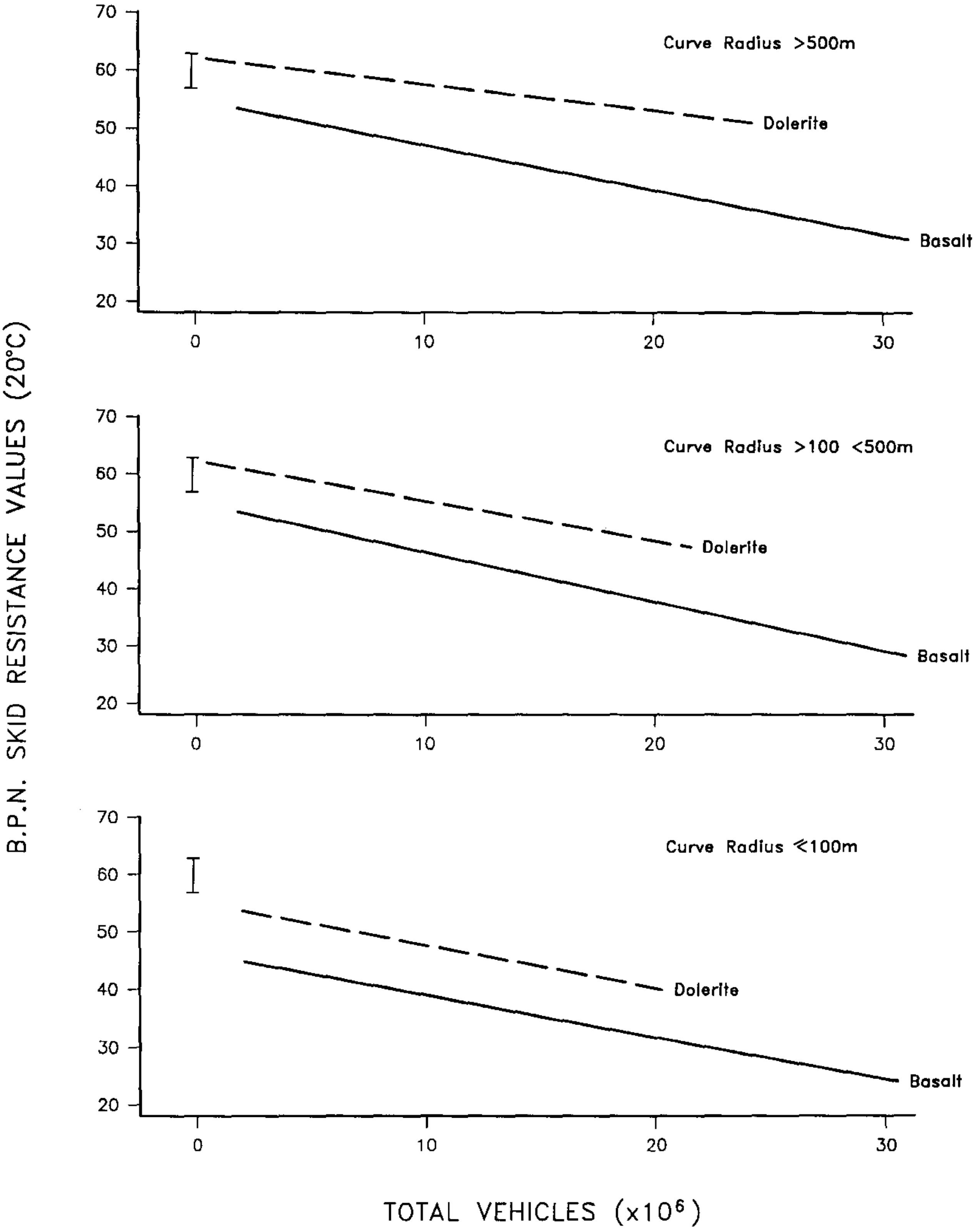
Results summary

Curve radii >100 m — Steady decline in BPN value from initial 60–65.

Curve radii <100 m — More rapid decline than above for the first 2.5×10^6 vehicles, but less than for basalt, followed by steady decline in BPN with continued traffic.

Lowest BPN value — 45 at 17.5×10^6 vehicles for curve radius less than 100 metres.

The results show that dolerites maintained higher levels of skid resistance, considered significant in the high traffic stress situations.



(I – Typical range of B.P.N. values on new, untrafficked surface.)

(From DRT Report 85/93)

Figure 2

Physical properties of dolerite — BPN skid resistance versus total vehicles

5 cm

CONCLUSIONS

The results reported in the body of this report indicate a range of physical properties for dolerite rock. The results were obtained from five locations. Variations in the properties of dolerite appear to be largely related to the degree of weathering and rock defects. Other factors, such as composition and grainsize, probably play a less important role in determining rock properties.

The Pieman (1983) results indicate differences in properties of good quality 'fresh' rock within the quarry. The results are interesting but no petrographic information was reported. The only reported differences were that the 'soft' rocks had slightly discoloured joints, evident in the broken uniaxial and point load specimens. Defects, and possibly slight weathering, appear to produce the difference in properties.

Comparative testing of basalt and dolerite indicates that dolerite has better properties for road seals. Dolerite has better polished stone values and skid resistance properties.

The results are considered to be representative of the general quality of dolerite currently quarried. However, not all results provided a description of the rock tested or the method of testing. Therefore they are only considered to be indicative of each site and cannot be assumed to apply elsewhere. The results provide an overview of physical properties but do not replace specific site testing.

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